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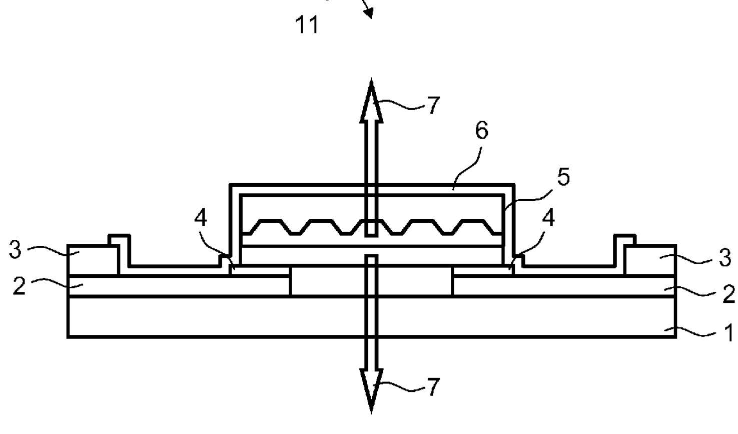
(54) **Title**: LIGHT-EMITTING DEVICE AND METHOD FOR MANUFACTURING A LIGHT- EMITTING DEVICE

FIG. 1I



(57) **Abstract**: A light-emitting device is describe which comprises a transparent carrier plate (1), at least two transparent conductor lines (2) on the transparent carrier plate (1), at least one light-emitting semiconductor chip (5) being arranged on the at least two transparent conductor lines (2) and being electrically connected to the at least two transparent conductor lines (2) by a transparent electrically conductive glue (4), and a parylene coating (6) covering the at least one light-emitting semiconductor chip (5) and the at least two transparent conductor lines (2). Furthermore, a method for manufacturing a light-emitting device is described.

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Description

Light-emitting device and method for manufacturing a light-emitting device

A light-emitting device and a method for manufacturing a light-emitting device are described.

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When assembling displays and lighting devices based on light-emitting diodes (LED), complex and costly steps as for example wire bonding, casting and plating have to be performed. Particularly in transparent display and lighting applications the bond wires and the usually packaged LEDs are visible, which can be undesirable.

It is an object of at least one embodiment to provide a light-emitting device. It is a further object of at least one embodiment to provide a method for manufacturing a light-emitting device.

These objects are achieved by means of the subject matters of the independent patent claims. The dependent patent claims, which are hereby explicitly incorporated to the description by reference, relate to advantageous configurations and developments.

According to at least one embodiment, a light-emitting device comprises a transparent carrier plate with at least two transparent conductor lines on the carrier plate. In particular, the transparent conductor lines can be arranged directly on a mounting surface on a mounting side of the transparent carrier plate.

Furthermore, the light-emitting device comprises at least one light-emitting semiconductor chip which is arranged on the at least two transparent conductor lines. The light-emitting semiconductor chip is electrically connected to the at least two transparent conductor lines by a transparent electrically conductive glue. A portion of the transparent electrically conductive glue can in particular be arranged between a transparent conductor line and the light-emitting semiconductor chip and establish and/or mediate an electrical connection between the transparent conductor line and an electrode of the light-emitting semiconductor chip. The light-emitting semiconductor chip can be in particular an unpackaged chip that is free of a housing and that is mounted directly on the transparent conductor lines by the transparent electrically conductive glue.

By virtue of the transparent electrically conductive glue it can be possible to omit wire bonds and solder connections, which could be visible for an external observer, between the light-emitting semiconductor chip and the transparent conductor lines for electrically connecting the at least one light-emitting semiconductor chip.

Furthermore, a parylene coating is arranged over the at least one light-emitting semiconductor chip and over the at least two transparent conductor lines covering the at least one light-emitting semiconductor chip and the at least two transparent conductor lines. The parylene coating can preferably be formed as continuous layer over said components of the light-emitting device. Moreover, at least regions of the transparent carrier plate which are free of transparent conductor lines and light-emitting semiconductor chips can be covered by the parylene coating. In particular, the parylene coating can be directly applied to said components of the light-emitting device.

According to at least one further embodiment, for a method for manufacturing a light-emitting device a transparent carrier plate is provided. Furthermore, at least two transparent conductor lines are provided on the transparent carrier plate. A transparent electrically conductive glue is applied on each of the at least two transparent conductor lines and at least one light-emitting semiconductor chip is arranged on the at least two transparent conductor lines and is electrically connected to the at least two transparent conductor lines by the transparent electrically conductive glue. Furthermore, a parylene coating covering the at least one light-emitting semiconductor chip and the at least two transparent conductor lines is applied.

The features and embodiments described herein relate to both the light-emitting device and the method for manufacturing the light-emitting device, respectively.

Here and in the following, “light” denotes electromagnetic radiation having a wavelength or a combination of wavelengths ranging from ultra-violet to infrared. According to preferred embodiments, the light emitted by the at least one light-emitting semiconductor chip is visible light, for example light with a color comprising blue, cyan, green, yellow, orange, amber, red, magenta and combinations therefore, such as for example multi-colored light and white light.

Here and in the following “transparent” can mean that an element is at least partly transmissive for light, in particular for visible light. A transparent element can provide a clear transmission of light or a diffuse transmission of light. Consequently, transaprent elements explained herein can also be translucent.

In the following, the at least one light-emitting semiconductor chip can also be denoted as light-emitting chip, as semiconductor chip or as chip.

In the following, the transparent carrier plate, the transparent conductor lines and the transparent electrically conductive glue can also be referred to as carrier plate, plate or carrier, as conductor lines, and as electrically conductive glue, conductive glue, transparent glue or glue, respectively.

According to at least one further embodiment, the at least one light-emitting semiconductor chip is embodied as light-emitting diode chip (LED chip) and comprises an epitaxially grown semiconductor layer sequence with an active region for generating light.

For example, the chip can be embodied on the basis of InGaAlN. InGaAlN-based light-emitting chips and InGaAlN-based semiconductor layer sequences include, in particular, a semiconductor layer sequence composed of different individual layers and containing at least one individual layer comprising a material from the III-V compound semiconductor material system $In_xAl_yGa_{1-x-y}N$ where $0 \leq x \leq 1$, $0 \leq y \leq 1$ and $x + y \leq 1$. A light-emitting chip having a semiconductor layer sequence with at least one active region based on InGaAlN can, for example, preferably emit electromagnetic radiation in an ultraviolet to green wavelength range.

Alternatively or additionally, the at least one light-emitting semiconductor chip can also be based on InGaAlP, that is to say that the chip can have different individual layers, of which at least one individual layer comprises a material from the III-V compound semiconductor material system $In_xAl_yGa_{1-x-y}P$ where $0 \leq x \leq 1$, $0 \leq y \leq 1$ and $x + y \leq 1$. A light-emitting chip having a semiconductor layer sequence with at least one active region based on InGaAlP can, for example, preferably emit electromagnetic radiation having one or more spectral components in a green to red wavelength range.

Alternatively or additionally, the at least one light-emitting semiconductor chip can also comprise other III-V compound semiconductor material systems such as, for instance, an AlGaAs-based material or a II-VI compound semiconductor material system. In particular, a light-emitting semiconductor chip comprising an AlGaAs-based material can be suitable for emitting electromagnetic radiation having one or more spectral components in a red to infrared wavelength range. A II-VI compound semiconductor material can comprise at least one element from the second main group or the second subgroup such as Be, Mg, Ca, Sr, Cd, Zn, Sn, for example, and an element from the sixth main group such as O, S, Se, Te, for example. In particular, a II-VI compound semiconductor material comprises a binary, ternary or quaternary compound comprising at least one element from the second main group or second subgroup and at least one element from the sixth main group. Moreover, such a binary, ternary or quaternary compound can comprise, for example, one or more dopants and additional constituents. By way of example, the II-VI compound semiconductor materials include ZnO, ZnMgO, CdS, ZnCdS, MgBeO.

The at least one light-emitting semiconductor chip can furthermore have a substrate, on which a semiconductor layer sequence comprising one or more of the above-mentioned III-V or II-VI compound semiconductor materials are deposited. The substrate can for example comprise an electrically insulating material or a semiconductor material, for instance a compound semiconductor material system as mentioned above. For example, the substrate can comprise sapphire, GaAs, GaP, GaN, InP, SiC, Si and/or Ge or be composed of such a material.

The semiconductor layer sequence of the at least one light-emitting semiconductor chip can have as active region a layer or a layer stack forming a conventional pn junction, a double heterostructure, a single quantum well structure (SQW structure) or a multiple quantum well structure (MQW structure). In the context of the application, the designation "quantum well structure" encompasses, in particular, any structure in which charge carriers can experience a quantization of their energy states as a result of confinement. In particular, the designation quantum well structure does not include any indication about the dimensionality of the quantization. It therefore encompasses, inter alia, quantum wells, quantum wires and quantum dots and any combination of these structures.

The semiconductor layer sequence of the at least one light-emitting semiconductor chip can comprise in addition to the active region further functional layers and functional regions, for instance chosen from undoped, p- and n-doped layers as charge carrier transport layers, charge carrier confinement layers, cladding layers, waveguide layers, barrier layers, planarization layers, buffer layers, protective layers.

The semiconductor layer sequence of the at least one light-emitting chip can be deposited on the substrate by epitaxial growing, for example by metal-organic vapor-phase deposition (MOVPE) or molecular-beam epitaxy (MBE). In this case, the substrate of the chip is a growth substrate. Alternatively, instead of a growth substrate the substrate of the chip can also be a carrier substrate for the semiconductor layer sequence, to which the semiconductor layer sequence, which has been grown on a previously provided growth substrate, has been transferred. In this case, the chip can for example be embodied as thin-film light-emitting diode chip.

A thin-film light-emitting diode chip can have, in particular, one or more of the following characteristic features:

- a reflective layer is applied or formed at a first main area - facing toward a carrier element - of a radiation-generating epitaxial layer sequence, said reflective layer reflecting at least part of the electromagnetic radiation generated in the epitaxial layer sequence back into the latter;
- the epitaxial layer sequence has a thickness in the range of 20 µm or less, in particular in the region of 10 µm; and/or
- the epitaxial layer sequence contains at least one semiconductor layer having at least one area having an intermixing structure which ideally leads to an approximately ergodic distribution of the light in the epitaxial layer sequence, that is to say that it has an as far as possible ergodically stochastic scattering behavior. The epitaxial

layer sequence of a thin-film light-emitting diode chip can be transferred to a carrier substrate after growth on a growth substrate by means of rebonding.

Furthermore, the light-emitting semiconductor chip can be free of a substrate, which means that the growth substrate is removed after growing the semiconductor layer sequence and that no carrier substrate is applied. Semiconductor chips which are free of a substrate can be denoted as substrate-less chips.

Furthermore, the at least one light-emitting semiconductor chip can comprise at least two electrodes by means of which the semiconductor layer sequence and, in particular, the active region can be electrically contacted. The electrodes can be formed on a same or on different surfaces of the chip and can be formed as structured or unstructured electrode layers, as electrically conducting vias or as combinations thereof.

According to a preferred embodiment, the electrodes of the at least one light-emitting semiconductor chip are arranged on the same side of the chip so that the chip can be mounted on the transparent conductor lines and the transparent carrier plate by positioning the electrodes on the conductor lines and connecting the electrodes to the conductor lines. For example, the at least one light-emitting semiconductor chip can be embodied as so called flip-chip, having two electrodes on a same side of the semiconductor layer sequence which is remote from the substrate, preferable a growth substrate. Alternatively, the chip can comprise one or more electrical vias embodied as electrodes or at least as parts of electrodes, wherein the vias reach through the substrate, which can be electrically insulating, so that the chip can be electrically connected through the substrate. Moreover, it can be possible that the substrate is electrically conducting and that one electrode of the chip is at least partly formed by the substrate. If the at least one light-emitting semiconductor chip is embodied as thin-film light-emitting diode chip, the electrodes can also be provided on a same side of the chip.

Furthermore, the at least one light-emitting semiconductor chip can be a transparent light-emitting semiconductor chip. In this case, the chip can preferably comprise a transparent substrate or can be substrate-less. Particularly in case of the light-emitting chip having a transparent substrate, for example when being embodied as flip-chip, the chip can emit light through the substrate as well as in a direction leading away from the substrate. Preferably, the transparent chip can emit light in all directions. The at least one transparent light-emitting semiconductor chip can advantageously be used in a light-emitting device which emits light through the transparent carrier plate as well as in a direction leading away from the carrier plate. Such light-emitting device can be for example a transparent lighting device or a transparent display device.

Furthermore, the at least one light-emitting semiconductor chip can comprise a wavelength conversion substance, which can be applied in the form of a potting or a surface coating on or above the semiconductor layer sequence and/or the substrate. The wavelength conversion substance can be suitable for converting at least part of the light emitted by the active region of the chip, which light can lie for instance in an ultraviolet to blue spectral range, into light with a longer wavelength, for instance into light having one or more spectral components in a green and/or a yellow and/or a red wavelength range. As a result of the emitted light being superimposed with the converted light, it is possible that a mixed-colored, for example white, luminous impression of the emitting chip can be generated.

The wavelength conversion substance can comprise one or more of the following materials: garnets of the rare earths and of the alkaline earth metals, for example YAG:Ce^{3+}, nitrides, nitridosilicates, sions, sialons, aluminates, oxides, halophosphates, orthosilicates, sulfides, vanadates, perylenes, coumarin and chlorosilicates. Furthermore, the wavelength conversion substance can also comprise suitable mixtures and/or combinations thereof. Furthermore, the wavelength conversion substance can be embedded in a transparent matrix material that surrounds or contains the wavelength conversion substance. The transparent matrix material can comprise, for example, silicones, epoxides, acrylates, imides, carbonates, olefins or derivatives thereof in the form of monomers, oligomers or polymers as mixtures, copolymers or compounds therewith. By way of example, the matrix material can be an epoxy resin, polymethyl methacrylate (PMMA) or a silicone resin.

Furthermore, the light generated by the at least one light-emitting semiconductor chip can be determined solely by the choice of the materials of the epitaxial layer sequence, as explained above, without the use of a wavelength conversion substance.

According to at least one further embodiment, the light-emitting device comprises a plurality of light-emitting semiconductor chips. In this embodiment, the plurality of light-emitting semiconductor chips and a plurality of transparent conductor lines are arranged on the transparent carrier plate and each of the plurality of light-emitting semiconductor chips is arranged on two transparent conductor lines and is electrically connected to the respective two transparent conductor lines by a transparent electrically conductive glue.

All of the plurality of chips may emit light with the same or with a similar spectral distribution and intensity. Alternatively, at least two of the plurality of chips may emit light with different spectral distributions. In other words, at least two of the plurality of light-emitting semiconductor chips may emit light with different colors.

Furthermore, the plurality of chips may be arranged forming an array of light-emitting chips for an areal lighting device or a display device, wherein each of the chips defines a pixel. Moreover, groups of chips emitting light with a same color or different colors can define pixels of the display device, wherein the individual chips of a group of chips form sub-pixels. For example, a group of chips may contain at least one chip for emitting blue, green and red light, respectively, or cyan, magenta and yellow light, respectively, so that the light-emitting device can be embodied as fill-color display device. When operating chips emitting the same colored light simultaneously, the light-emitting device can also be embodied as areal lighting device with a controllable color.

Furthermore, the plurality of light-emitting semiconductor chips can be connected in series and/or in parallel by the transparent conductor lines. A connection in series or in parallel of all of the chips can be advantageously for a light-emitting device which is a lighting device so that all chips can be operated simultaneously and only two contact elements as described in the following are required as an anode contact and an cathode contact for electrically connecting the plurality of chips.

According to at least one further embodiment, the light-emitting device comprises at least two electrical contact elements on transparent conductor lines for electrically contacting the at least one light-emitting semiconductor chip. The electrical contact elements, which can form an anode and a cathode contact element, can preferably comprise aluminum or can consist of aluminum. The contact elements can for example form bond pads which can be connectable to an external circuit or driver to control the light-emitting device. The contact elements can be applied by an evaporation process using a mask. In particular, the at least two electrical contact elements for electrically contacting the at least one light-emitting semiconductor chip are applied on transparent conductor lines before the parylene coating is applied.

In case the light-emitting device comprises a plurality of light-emitting semiconductor chips which are to be controlled independently and individually, for example in a display application, the light-emitting device can comprise a plurality of contact elements in order to electrically contact each of the chips or groups of chips individually.

According to at least one further embodiment, for providing the at least two conductor lines, a precursor layer comprising a transparent conductive oxide or precursors for forming a transparent conductive oxide are applied to the carrier plate. The transparent conducting oxide may for instance comprise a transparent conducting metal oxide as zinc oxide, tin oxide, cadmium oxide, titan oxide, indium oxide or indium tin oxide (ITO). Furthermore, alternatively or additionally to binary compounds a transparent conductive oxide may comprise ternary compounds including two of Zn, Sn, Cd, Mg, In and Ga and O. Preferably, the transparent conductor lines comprise ITO or consist of ITO.

For forming the precursor layer, the transparent conductive oxide can be applied by an evaporation process and a photolithography process in order to structure the transparent electrically conducting layer to form the at least two transparent conductor lines. In a further preferred embodiment, the transparent conductive oxide is applied using a sol-gel process. In such process, which is described for example in prior art document Qiang Wei et al. "Direct patterning ITO transparent conductive coatings", Solar Energy Materials & Solar Cells 68, p. 383 - 390, 2001, polymeric precursors of the transparent conductive oxide are provided and are applied to the carrier plate by dip coating or spin coating forming the precursor layer. The polymeric film can be patterned by using a photomask and ultraviolet (UV) irradiation and can be developed in an organic solvent in order to remove those portions of the polymeric film which have not been exposed to the UV irradiation. Afterwards, the precursor layer is sintered and/or annealed in order to finalize the at least two transparent conductive lines on the carrier plate.

According to at least one further embodiment, the parylene coating can comprise or can be formed from poly-para-xylylene, which is also known as Parylene N. Furthermore, the parylene coating can comprise or can be formed from Parylene C, which comprises a substitute chlorine atom for one of the aromatic hydrogen atoms, or Parylene D, which comprises two substitute chlorine atoms for two aromatic hydrogen atoms. Alternatively or additionally, the parylene coating can comprise or can be formed from fluorinated parylene derivates, for example derivates known as Parylene AF-4 or Parylene VT-4.

According to at least one further embodiment, the parylene coating forms a continuous layer and covers all of the side of the light-emitting device on which the at least one light-emitting semiconductor chip is arranged except regions over the electrical contact elements. Preferably, the parylene coating is applied unstructured so that the parylene coating covers all of the side of the light-emitting device on which the at least one light-emitting semiconductor chip is situated. Afterwards, the parylene coating can be removed in regions over the electrical contact elements, for example by laser scribing, thereby exposing the contact elements at least partly.

According to at least one further embodiment, the transparent carrier plate comprises a material or a material combination that is transparent and provides sufficient structural stability to carry all other elements of the light-emitting device. Preferably, the transparent carrier plate comprises glass or is a glass plate. Alternatively or additionally, the carrier plate can comprise or consist of a transparent plastic in the form of a plastic layer or a laminate.

Furthermore, the carrier plate can be formed as glass-plastic laminate.

According to at least one further embodiment, a side of the carrier plate that is remote from the at least one light-emitting semiconductor chip is covered by a reflective layer. Preferably, the reflective layer comprises aluminum or consists of aluminum. By virtue of the reflective layer, a one-side emitting light-emitting device can be formed which emits light only through the parylene coating along a direction leading away from the carrier plate.

According to at least one further embodiment, the light-emitting device comprises a plurality of stacked transparent carrier plates, wherein a plurality of light-emitting semiconductor chips and a plurality of transparent conductor lines are arranged on each of the transparent carrier plates and wherein each of the plurality of light-emitting semiconductor chips is arranged on two transparent conductor lines and electrically connected to the two transparent conductor lines by a transparent electrically conductive glue. In other words, the light-emitting device comprises a plurality of light-emitting units, each of the units comprising a transparent carrier plate with transparent conductor lines, preferably transparent light-emitting semiconductor chips connected to the conductor lines by a transparent electrically conductive glue, and a parylene coating. Each of the light-emitting units is preferably transparent so that the units can be visible through other units.

A light-emitting device comprising stacked light-emitting units can for example form a three-dimensional lighting application or a three-dimensional display application, for example having a cubic shape or another three dimensional form.

The light-emitting device described herein can form a lighting device as for example a car backlight, a preferably transparent window lighting device, a wall lighting device or a ceiling lighting device. Moreover, the light-emitting device can form a display device, preferably a transparent display device.

Further features, advantages and expediencies will become apparent from the following description of exemplary embodiments in conjunction with the Figures.

Figures 1A to 1I show schematic views of method steps of a method for forming a light-emitting device according to an embodiment and

Figures 2 to 7 show schematic views of light-emitting devices according to further embodiments.

Components that are identical, of identical type and/or act identically are provided with identical reference symbols in the Figures.

In Figures 1A to 1I, a method for manufacturing a light-emitting device 11 is shown.

In a first step of the method, as shown in Figure 1A, a transparent carrier plate 1 is provided. The carrier plate 1 is a glass plate.

Furthermore, a precursor layer 20 comprising a transparent conductive oxide or comprising precursors for forming a transparent conductive oxide is applied to the carrier plate 1. The precursor layer 20 is preferably applied to the carrier plate 1 by a sol-gel process, wherein polymeric precursors of the transparent conductive oxide are provided and applied to the carrier plate 2 by dip coating or spin coating. The polymeric film is applied continuously and unstructured, thereby forming an unstructured precursor layer 20.

In a further method step, as shown in Figure 1B, a mask 98 is applied and the polymeric film forming the precursor layer 20 is irradiated by UV radiation 90.

In a further method step, the irradiated precursor layer 20 can be developed in an organic solvent in order to remove those portions of the precursor layer 20 which have not been exposed to the UV radiation. Afterwards, the precursor layer 20 can be sintered and/or annealed so that the remaining portions of the precursor layer 20 form at least two transparent conductive lines 2 on the carrier plate 1, as shown in Figure 1C.

As shown in Figure 1D, by using a further mask 99, electrical contact elements 3 are applied to the at least to transparent conductor lines 2 by means of an evaporation process. The contact elements 3 are composed of aluminum and form bond pads which allow an electrically contacting the finished light-emitting device 11.

In a further method step, which is shown in Figure 1E, a transparent electrically conductive glue 4 is applied to the at least two transparent conductor lines 2 by dispensing portions of the glue 4 to the conductor lines 2. The transparent electrically conductive glue 4 can for example be or comprise commercially available transparent glue as for example Eccobond S3860C.

A light-emitting semiconductor chip 5 is attached to the glue portions, thereby electrically connecting and mounting the chip 5 to the at least two conductor lines 2 by the glue 4, as shown in Figure 1F. According to an exemplary embodiment, the light-emitting semiconductor chip 1 is a transparent light-emitting flip-chip having a transparent sapphire substrate 50, onto which a semiconductor layer sequence 51 with an active region 52 is grown. The chip 5 comprises electrodes (not shown) on a side of the semiconductor layer sequence 51 which is remote from the substrate 51, wherein the electrodes are connected to the conductor lines 2 by the transparent conductive glue 4. As indicated in Figure 1F, the substrate 51 can for example have a surface structure at the interface to the semiconductor layer sequence 52, which can increase the extraction of light from the chip 5. The light-emitting semiconductor chip 5 and, in particular, the active region 52 can for example comprise a InGaAlN compound semiconductor material as described in the general part of the description above for emitting blue or green light.

Alternatively to the embodiment of the chip 5 shown here, the chip 5 can comprise alternative or further features as described in the general part above.

In a further method step shown in Figure 1G, a coating process 91 is performed for covering the at least one light-emitting semiconductor chip 5 and the at least two transparent conductor lines 2 with a parylene coating 6. The finished parylene coating 6 is shown in Figure 1H. The parylene coating 6 can for example comprise or consist of Parylene C, which is known to provide an advantageous combination of electrical and physical properties and a low permeability to moisture and other harmful gases.

As shown in Figure 1H, the parylene coating 6 is applied unstructured and forms a continuous layer that covers all of the side of the carrier plate 1 on which the at least one light-emitting semiconductor chip 5 is arranged and all elements and components thereon.

Afterwards, the parylene coating 6 can be removed in regions over the electrical contact elements 3, for example by laser scribing 92, in order to expose the contact elements 3 at least partially so that the contact elements 3 are accessible for electrically contacting the finished light-emitting device 11.

Consequently, the finished light-emitting device 11, as shown in Figure 1I, comprises a transparent carrier plate 1, at least two transparent conductor lines 2 on the carrier plate 1, at least one light-emitting semiconductor chip 5 being arranged on the at least two transparent conductor lines 2 and being electrically connected to the at least two transparent conductor lines 2 by a transparent electrically conductive glue 4, and a parylene coating 6 covering the at least one light-emitting semiconductor chip 5 and the at least two transparent conductor lines 2.

The light-emitting device 11 further comprises electrical contact elements 3 on the conductor lines 2, wherein the parylene coating 6 covers all of the side of the light-emitting device 11 on which the chip 5 is arranged except of regions over the electrical contact elements 6.

As indicated in Figure 1I, the light-emitting device 11 is transparent everywhere except the regions where the electrical contact elements 6 are situated and can therefore emit light 7 through the carrier plate 1 and in a direction remote from the carrier plate 1.

In Figure 2 a light-emitting device 12 according to a further embodiment is shown, which additionally has a reflective layer 8 applied to the carrier plate 1 on the side remote from the light-emitting semiconductor chip 5. Accordingly, the light-emitting device 12 is emitting light only in the direction remote from the carrier plate. The reflective layer 8 can for example comprise or consist of aluminum.

In the following Figures, light-emitting devices according to further embodiments are shown, which are based on the light-emitting devices 11 and 12 according to the embodiments shown in Figures 1A to 2, wherein in contrast to the foregoing embodiments a plurality of light-emitting semiconductor chips is arranged on the carrier plate. Therefore, only further features and modifications in comparison to the previous embodiments are described.

In Figure 3, a light-emitting device 13 according to a further embodiment is shown in a top view, which can be for example a lighting device such as a car backlight or a window lighting.

The light-emitting device 13 comprises a plurality of light-emitting semiconductor chips 5, wherein each of the chips 5 is attached to two conductor lines 2 of a plurality of transparent conductor lines 5 by a transparent electrically conductive glue 4, respectively. By way of example, the light-emitting device 13 comprises a 3x3-matrix of light-emitting semiconductor chips 5. The number and the positions of the chips 5 can be varied according to the requirements of the application of the light-emitting device 13.

The light-emitting semiconductor chips 5 are connected in series and in parallel and can be contacted via a pair of electrical contact elements 3 situated at border portions of the carrier plate 1 and forming an anode contact and a cathode contact.

A parylene coating, which is not shown for the sake of clarity, is applied to cover the complete side of the light-emitting device 13 where the light-emitting semiconductor chips 5 are situated except the contact elements 3.

The light-emitting chips 5 can be for example be red light-emitting chips 5 for a car backlight application. For general illumination applications, for example as transparent window illumination, the chips 5 can emit white light or can emit different colored light which results in white light when superimposed.

In Figure 4, a light-emitting device 14 according to a further embodiment is shown which comprises pixels 9. Each of the pixels 9 is formed by one or more light-emitting semiconductor chips of one or more than one colors. The light-emitting device 14 can be based for example on the light-emitting device 11 of Figure 1H and can be transparent, or on light-emitting device 12 of Figure 2 and can be reflective.

As indicated by the hashed pixels 9, the chips forming the pixels 9 can be addressed and controlled individually by a plurality of conductor lines and control elements, so that for example pictures, letters or other information can be depicted by the light-emitting device 14.

In Figures 5A and 5B, a light-emitting device 15 is shown which is similar to the light-emitting device 14 of Figure 4 and which is a transparent display device, for example a LED display in a transparent panel.

In Figure 5A, the light-emitting device 15 is shown in a switched-off state, wherein the light-emitting device 15 is transparent. In Figure 5B, the light-emitting device 15 is shown in a switched-on state so that information can be depicted.

Figure 6 shows a light-emitting device according to further embodiment, which is a sign with permanent information that is for example printed on the carrier plate, wherein the information can be illuminated in a switched-on state of the light-emitting device 16 by a plurality of light-emitting semiconductor chips.

Figure 7 shows a light-emitting device 17 according to a further embodiment, which comprises a plurality of stacked light-emitting units, wherein each unit is formed by a transparent carrier plate 1 with a plurality of light-emitting semiconductor chips 5. For the sake of clarity only carrier plates 1 and light-emitting semiconductor chips 5 are shown. The light-emitting units can be manufactured and embodied as the light-emitting devices according to the foregoing embodiments. Preferably, each light-emitting unit is transparent so that units can be seen through other units.

The light-emitting device 17 can be a three-dimensional display, wherein the chips 5 can be addressed and controlled individually in order to depict three-dimensional pictures, letters or other information.

Alternatively or additionally to the features described in connection with the Figures, the embodiments shown in the Figures can comprise further features described in the general part of the description. Moreover, features and embodiments of the Figures can be combined with each other, even if such combination is not explicitly described.

The invention is not restricted by the description on the basis of the exemplary embodiments. Rather, the invention encompasses any new feature and also any combination of features, which in particular comprises any combination of features in the patent claims, even if this feature or this combination itself is not explicitly specified in the patent claims or exemplary embodiments.

Patent claims

1. A light-emitting device, comprising:

- a transparent carrier plate (1),
- at least two transparent conductor lines (2) on the transparent carrier plate (1),
- at least one light-emitting semiconductor chip (5) being arranged on the at least two transparent conductor lines (2) and being electrically connected to the at least two transparent conductor lines (2) by a transparent electrically conductive glue (4), and
- a parylene coating (6) covering the at least one light-emitting semiconductor chip (5) and the at least two transparent conductor lines (2).

2. Light-emitting device according to claim 1, wherein the light-emitting device comprises at least two electrical contact elements (3) on transparent conductor lines (2) for electrically contacting the at least one light-emitting semiconductor chip (5).

3. Light-emitting device according to claim 2, wherein the at least two electrical contact elements (3) comprise aluminum.

4. Light-emitting device according to claim 2 or 3, wherein the parylene coating (6) covers all of the side of the light-emitting device on which the at least one light-emitting semiconductor chip (5) is arranged except regions over the electrical contact elements (3).

5. Light-emitting according to one of the preceding claims, wherein the transparent conductor lines (2) comprise a transparent conductive oxide.

6. Light-emitting device according to claim 5, wherein the transparent conductor lines (2) comprise indium tin oxide.

7. Light-emitting device according to one of the preceding claims, wherein the transparent carrier plate (1) is a glass plate.

8. Light-emitting device according to one of the preceding claims, wherein a side of the carrier plate (1) that is remote from the at least one light-emitting semiconductor chip (5) is covered by a reflective layer (8).

9. Light-emitting device according to claim 8, wherein the reflective layer (8) comprises aluminum.

10. Light-emitting device according to one of the preceding claims, wherein a plurality of light-emitting semiconductor chips (5) and a plurality of transparent conductor lines (2) are arranged on the transparent carrier plate (1) and wherein each of the plurality of light-emitting semiconductor chips (5) is arranged on two transparent conductor lines (2) and electrically connected to the respective two transparent conductor lines (2) by a transparent electrically conductive glue (4).

11. Light-emitting device according to claim 10, wherein at least two of the plurality of light-emitting semiconductor chips (5) emit light with different colors.

12. Light-emitting device according to claim 10 or 11, wherein the plurality of light-emitting semiconductor chips (5) is connected in series and/or in parallel by the transparent conductor lines (2).

13. Light-emitting device according to one of the claims 10 to 12, wherein each of the plurality of light-emitting semiconductor chips (5) is electrically controllable individually and is electrically contactable by individual electrical contact elements (3).

14. Light-emitting device according to one of the preceding claims, wherein the light-emitting device forms a transparent display.

15. Light-emitting device according to one of the preceding claims, wherein the light-emitting device comprises a plurality of stacked transparent carrier plates (1), wherein a plurality of light-emitting semiconductor chips (5) and a plurality of transparent conductor lines (2) are arranged on each of the transparent carrier plates (1) and wherein each of the plurality of light-emitting semiconductor chips (5) is arranged on two transparent conductor lines (2) and electrically connected to the respective two transparent conductor lines (2) by a transparent electrically conductive glue (4).

16. Method for manufacturing a light-emitting device according to one of the claims 1 to 15, wherein
- a transparent carrier plate (1) is provided,
- a precursor layer (20) comprising precursors of a transparent conductive oxide is applied to the transparent carrier plate (1) using a sol-gel process,
- the precursor layer (20) is structured using UV radiation for forming at least two transparent conductor lines (2),
- a transparent electrically conductive glue (4) is applied on each of the at least two transparent conductor lines (2),
- at least one light-emitting semiconductor chip (5) is arranged on the at least two transparent conductor lines (2) and is electrically connected to the at least two transparent conductor lines (2) by the transparent electrically conductive glue (4), and
- a parylene coating (6) covering the at least one light-emitting semiconductor chip (5) and the at least two transparent conductor lines (2) is applied.

17. Method according to claim 16, wherein at least two electrical contact elements (6) are applied on transparent conductor lines (2) for electrically contacting the at least one light-emitting semiconductor chip (5) before applying the parylene coating (6)

18. Method according to claim 17, wherein the parylene coating (6) is applied unstructured so that the parylene coating (6) covers all of the side of the light-emitting device on which the at least one light-emitting semiconductor chip (5) is arranged, and wherein the

parylene coating (6) is removed in regions over the electrical contact elements (3).

19. Method according to claim 18, wherein the parylene coating (6) is removed by laser scribing.

FIG. 1A

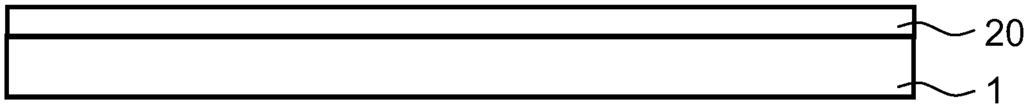


FIG. 1B

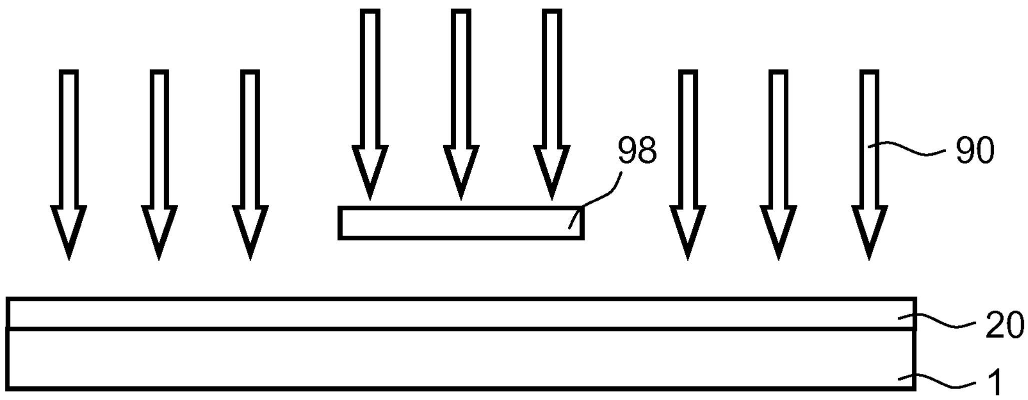


FIG. 1C

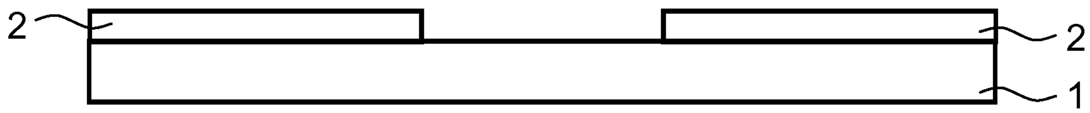


FIG. 1D

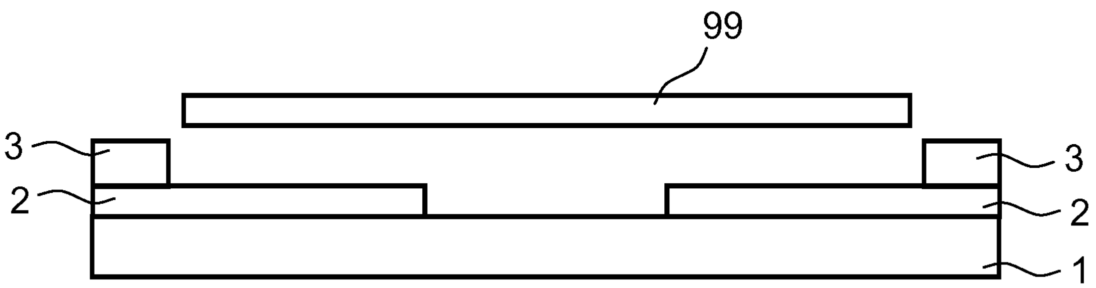


FIG. 1E

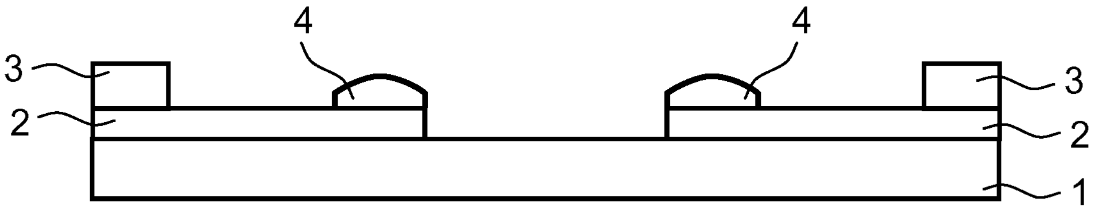


FIG. 1F

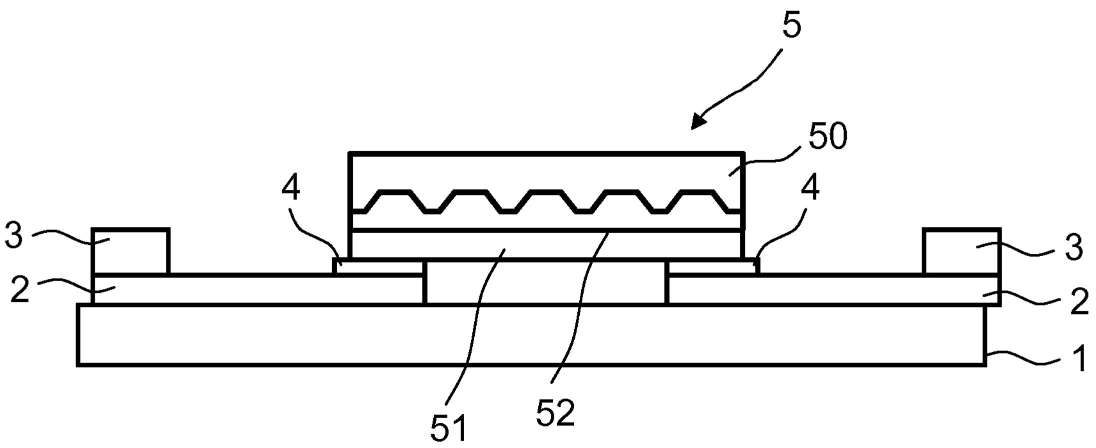


FIG. 1G

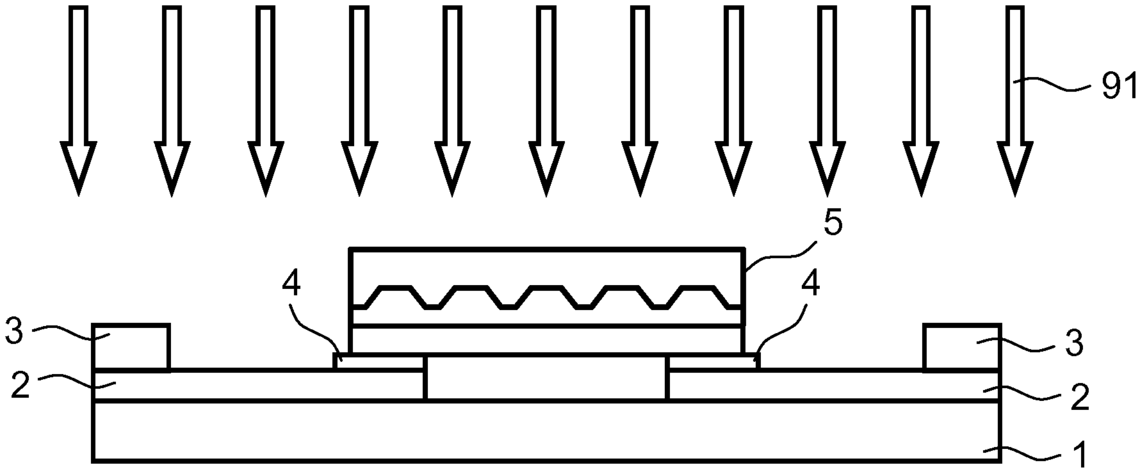


FIG. 1H

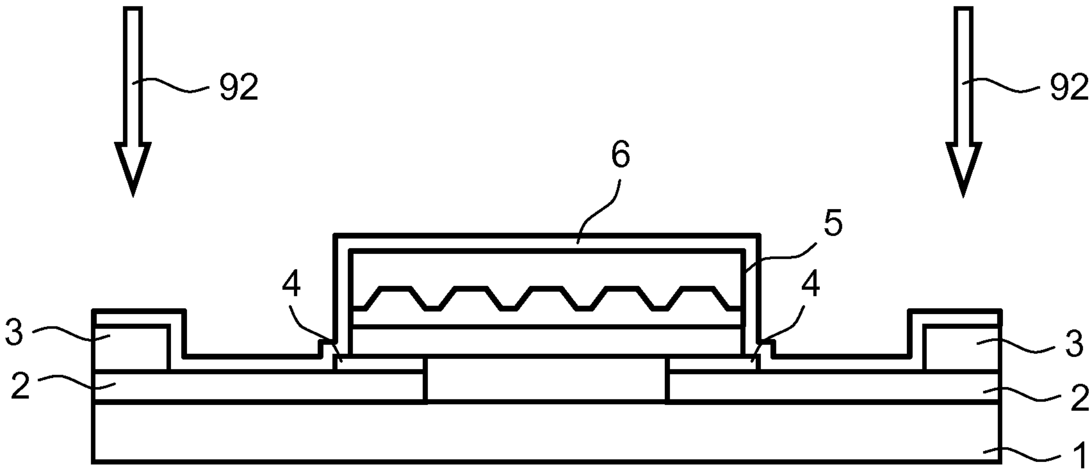


FIG. 1I

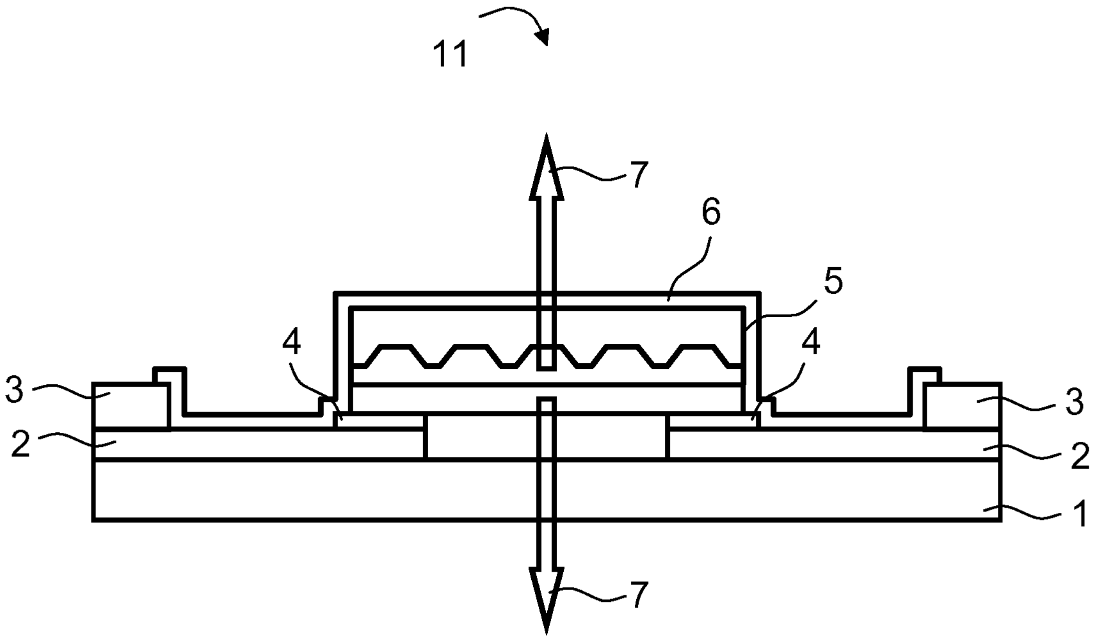


FIG. 2

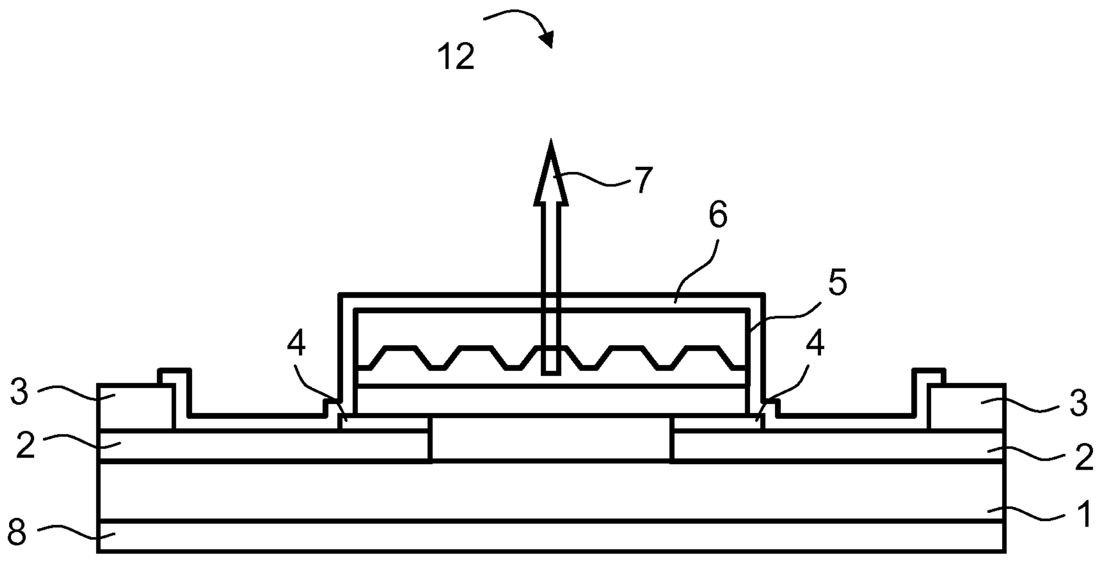


FIG. 3

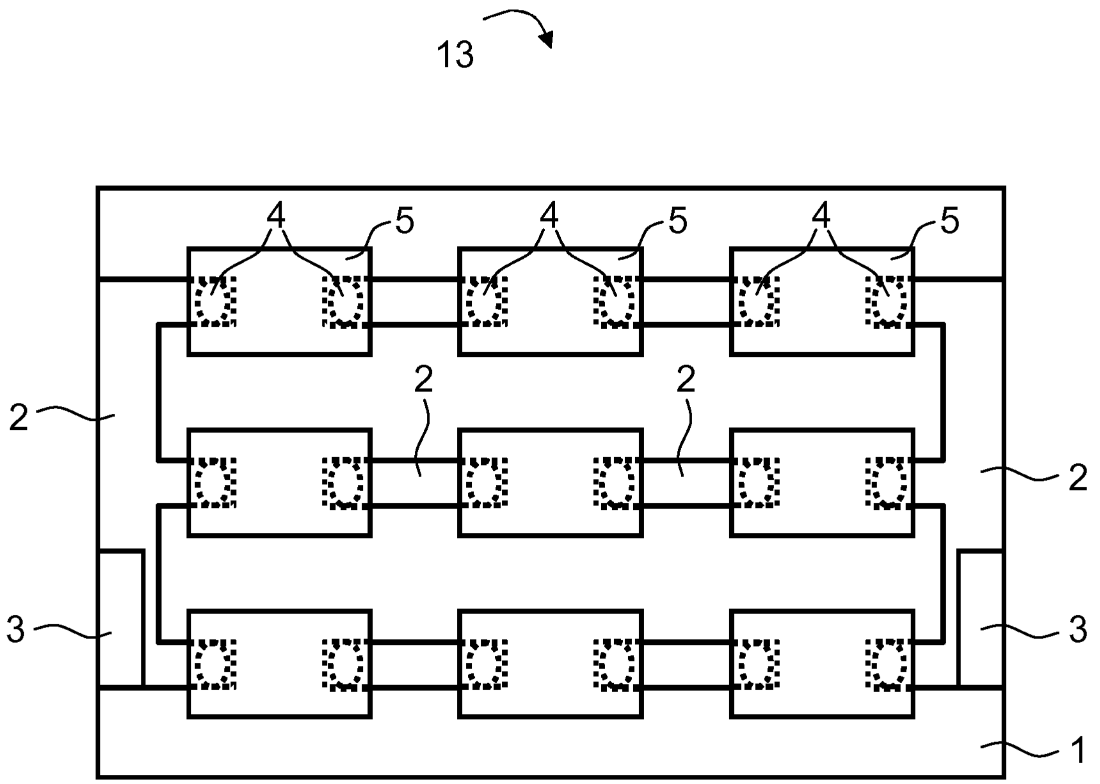


FIG. 4

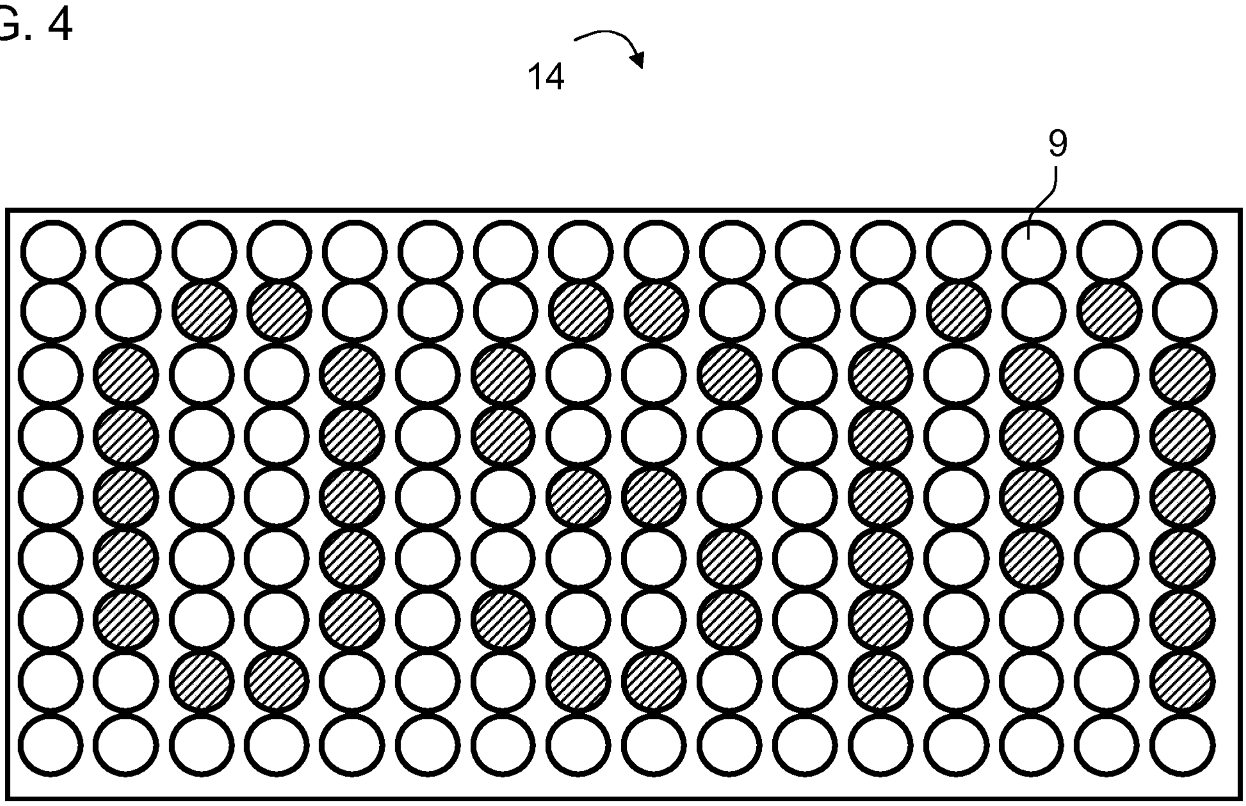


FIG. 5A

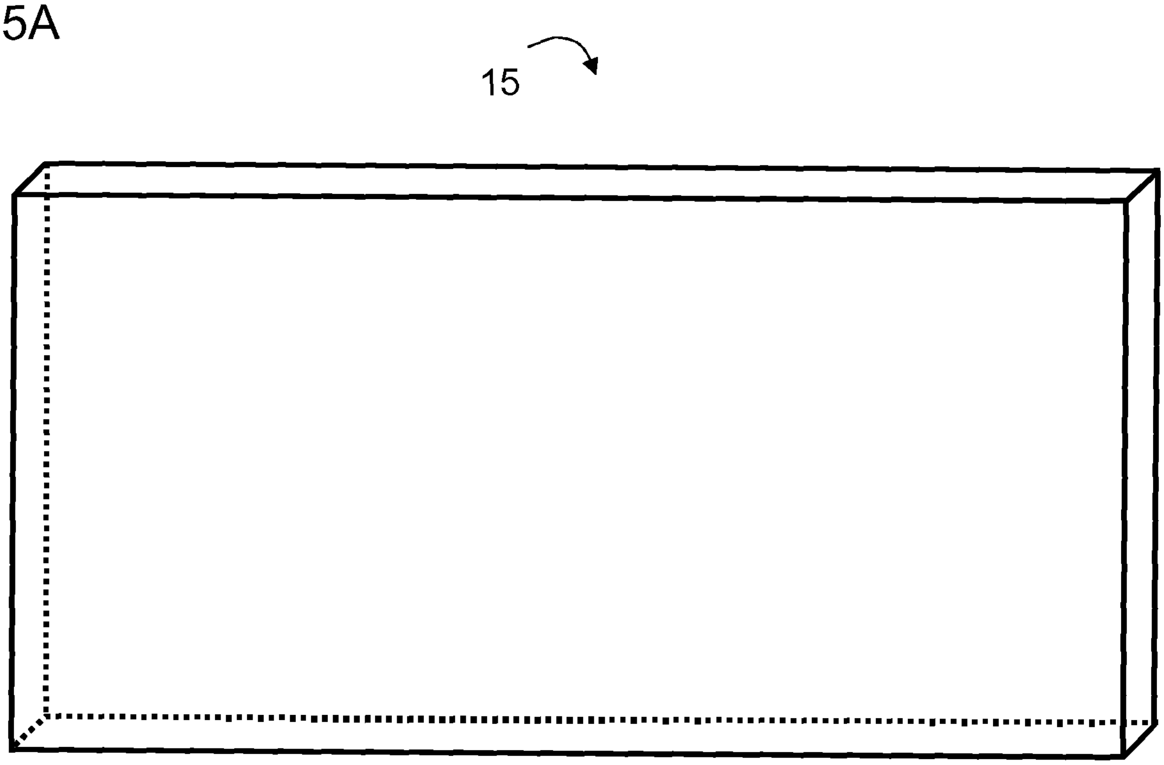


FIG. 5B

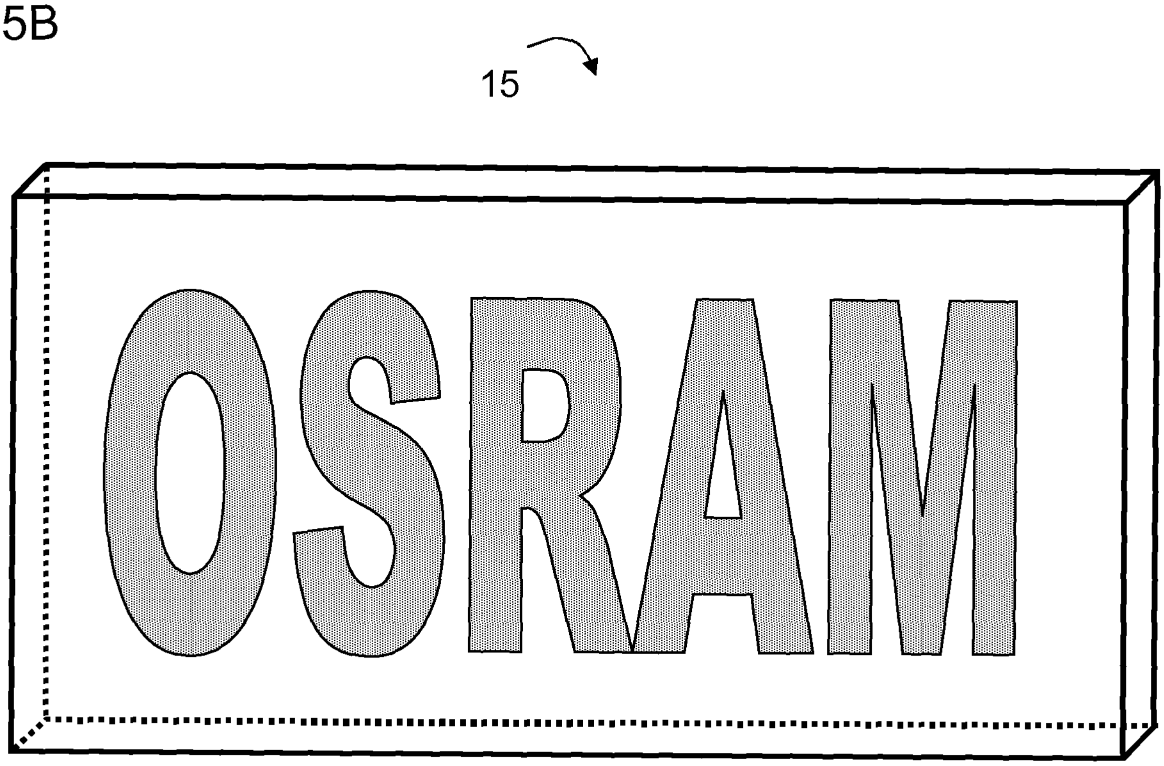


FIG. 6

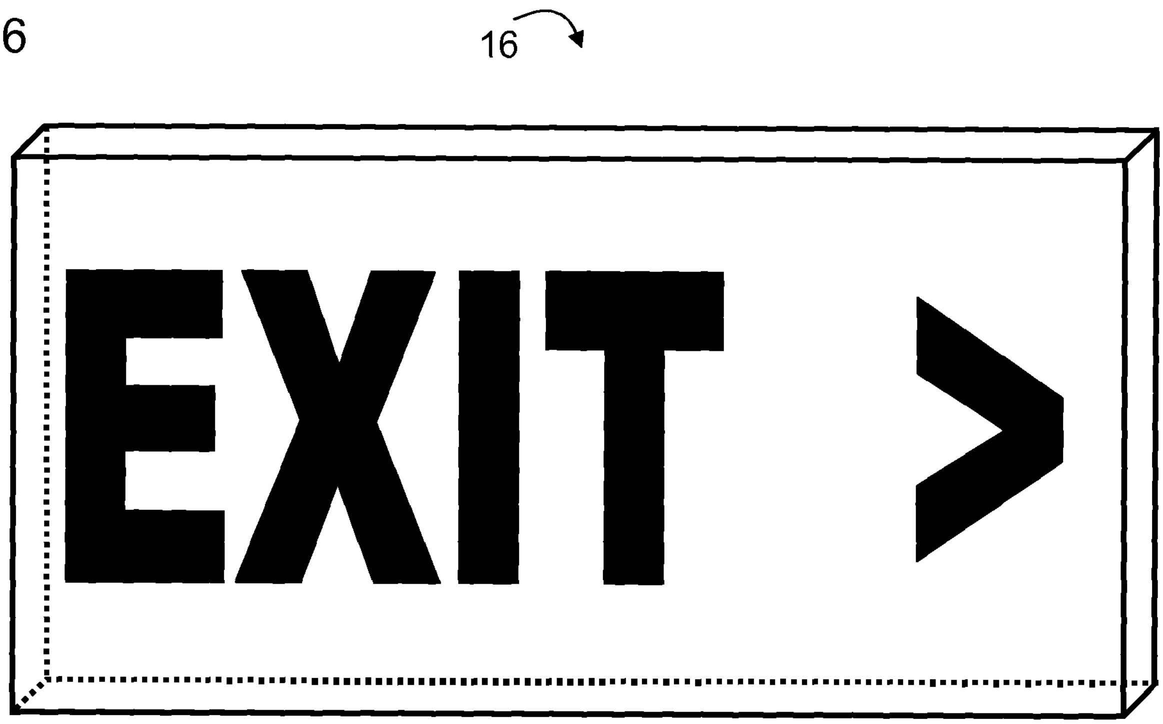
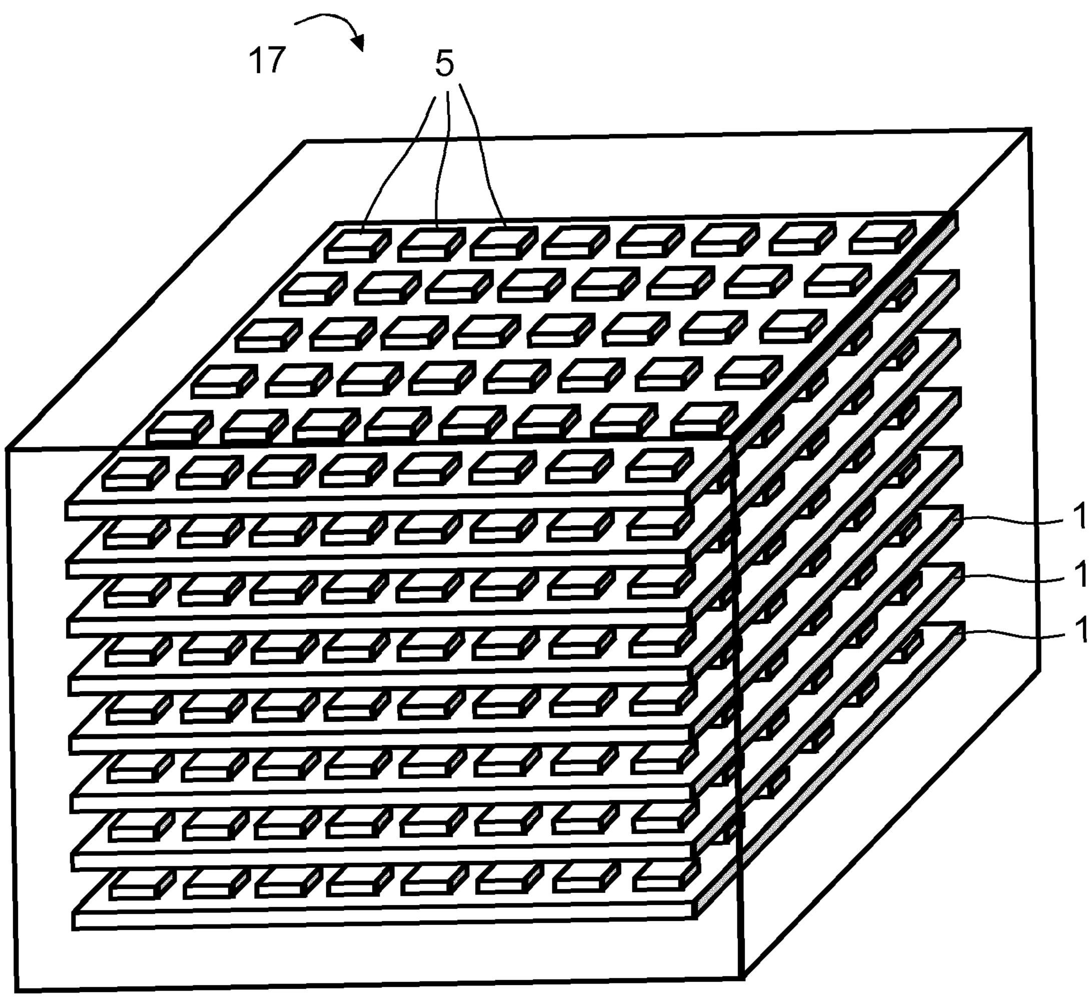


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/066698

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L33/44 H01L33/62 G09F9/33 B32B17/10
ADD. H01L33/56 H01L25/075 F21K99/00 G09F13/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L G09F B32B F21K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2011/031513 A1 (HSIEH MIN-TSUN [TW] ET AL) 10 February 2011 (2011-02-10) paragraphs [0005], [0024], [0034]; figure 7 -----	1-19
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2013	07/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Marani, Roberta

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/066698

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	WO 2012/050812 A2 (VERTICAL CIRCUITS INC [US]; BARRIE KEITH LAKE [US]; PANGRLE SUZETTE K) 19 April 2012 (2012-04-19) paragraph [0033]	2-4, 17-19
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Y	QIANG WEI ET AL.: "Direct patterning ITO transparent conductive coatings", SOLAR ENERGY MATERIALS & SOLAR CELLS, vol. 68, 2001, pages 383-390, XP4230577, cited in the application abstract	16-19

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PCT/EP2012/066698

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